RHIC Machine Performance in Runs 6 and 7
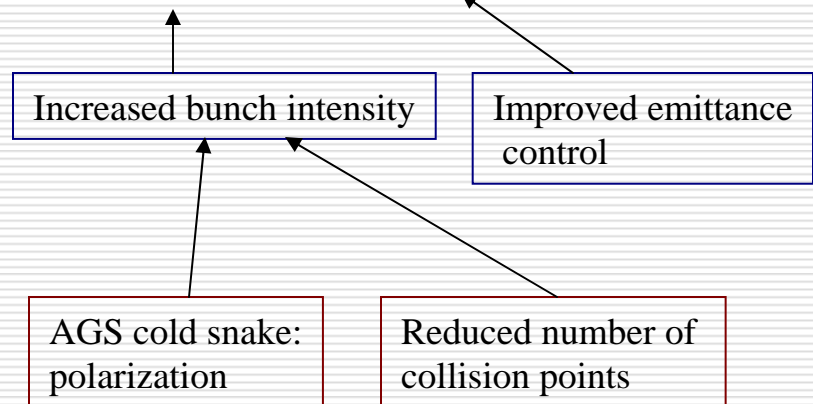
- ❑ Summary of Run 6
- ❑ Expectations and goals for Run 7
- ❑ Run-7 in a nutshell
- ❑ Compare Run 6 and Run 7
- ❑ Conclusions

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Polarized protons performance at 100 GeV (last three runs)

Parameter	Unit	2004	2005	2006
No. of bunches	--	56	106	111
bunch intensity	10^{11}	0.7	0.9	1.35
β^*	m	1	1	1
emittance	mm mrad	18	28	**18**
peak luminosity	$10^{30} cm^{-2} s^{-1}$	6	10	**35**
average luminosity	$10^{30} cm^{-2} s^{-1}$	4	6	**20**
collision points	--	4	3	2
time in store	%	41	56	**46**
average polarization, store	%	46	47	**65%**

Luminosity gain in run-6:

$$2.2 \ X \ 1.5 = 3.3$$

Increased bunch intensity

Improved emittance control

AGS cold snake: polarization

Reduced number of collision points

Courtesy V. Ptitsyn

Integrated luminosity: 100 GeV run

Run6 100 x 100 GeV pp Integrated Luminosity (Final Delivered) for Physics

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Polarization during 100 GeV run

polarization for Run 6, 100x 100 GeV - final

Run-5
Average Pol
49%
45%
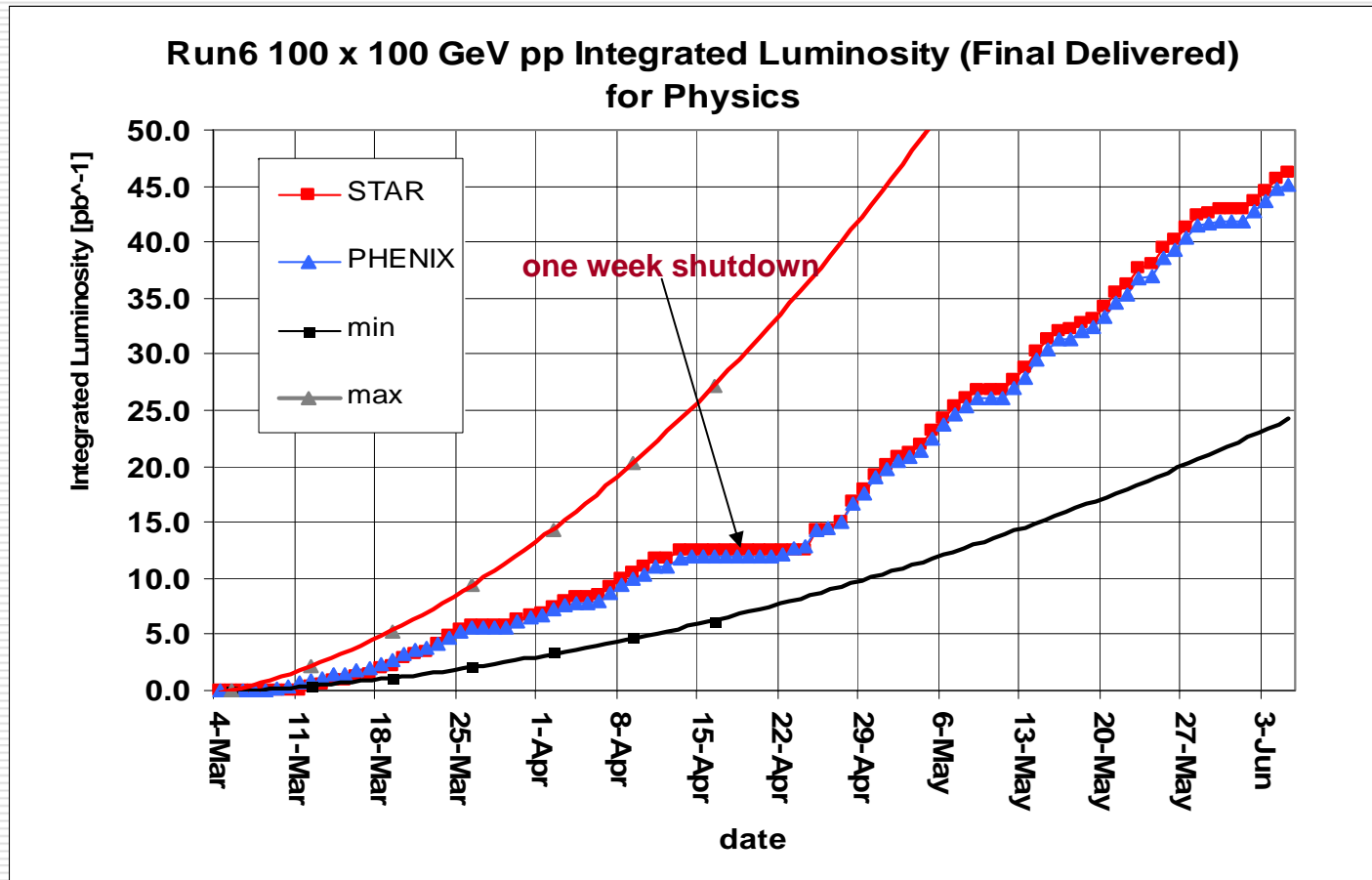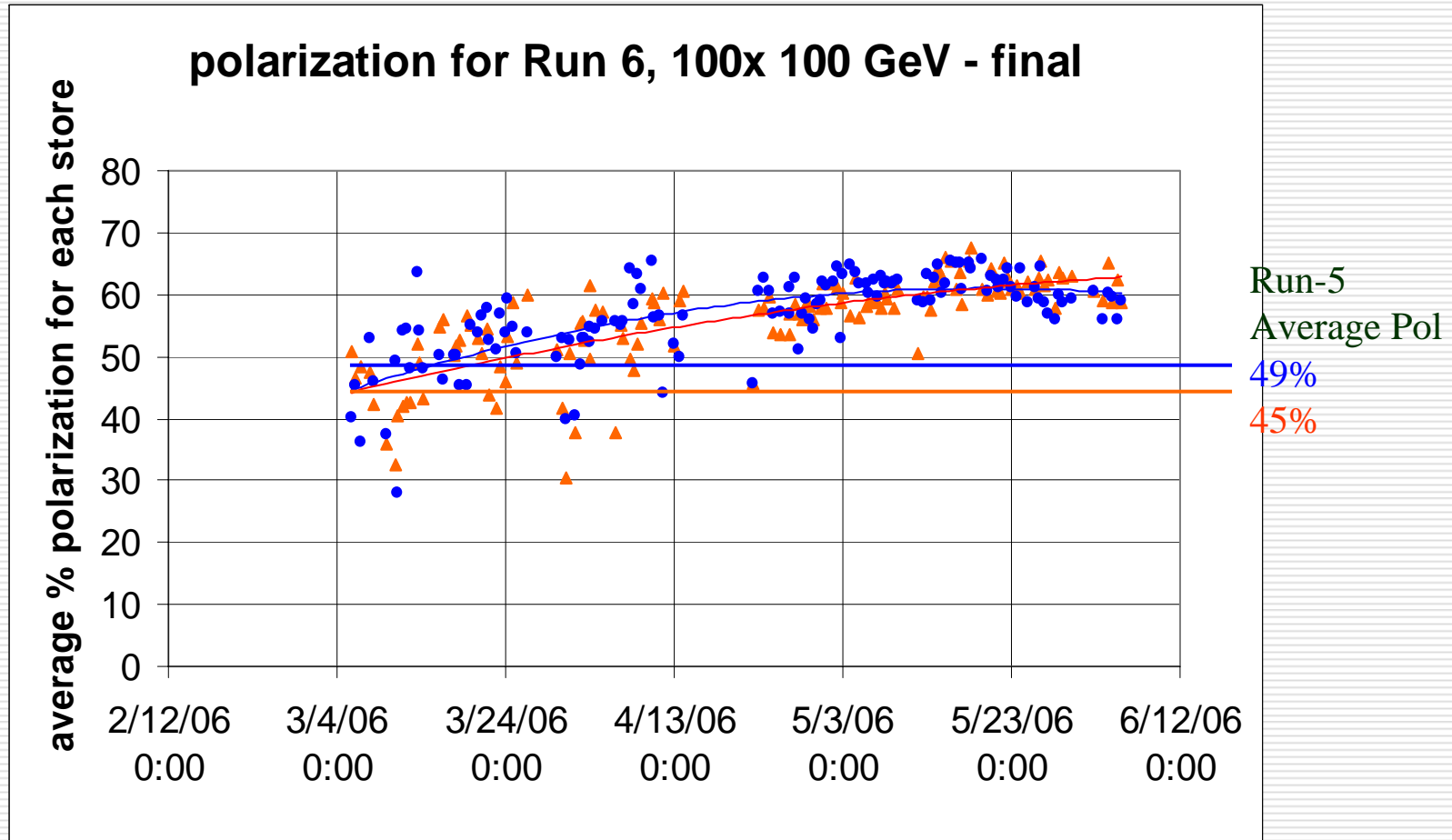
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# Expectations and Goals for Run-7

- Do better than Run-4 ;)   yes
- Increase number of bunches to 111   yes
- Reach 60% time at store on average   No!
- Reach avg. luminosity/store   yes
    - $> 8\ 10^{26}$ cm-2 s-1 routinely
- Reach peak luminosity/store   yes
    - $> 30\ 10^{26}$ cm-1 s-1
- Increase bunch intensity   no

Achieved beam parameters for Run7

- Avg. Luminosity gain: x2-3
- Int. Luminosity gain: x2
- Peak Luminosity gain: x2-2.5
- Reached maximum
  - Number of bunches
  - Transition crossing/bunch intensity
  - Luminosity lifetime? -> cooling
  - Transv. emittance preservation?
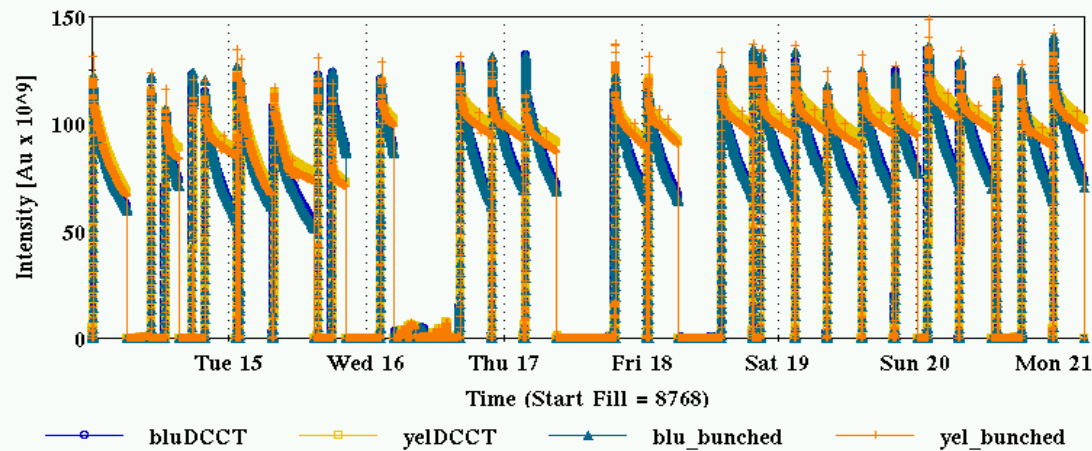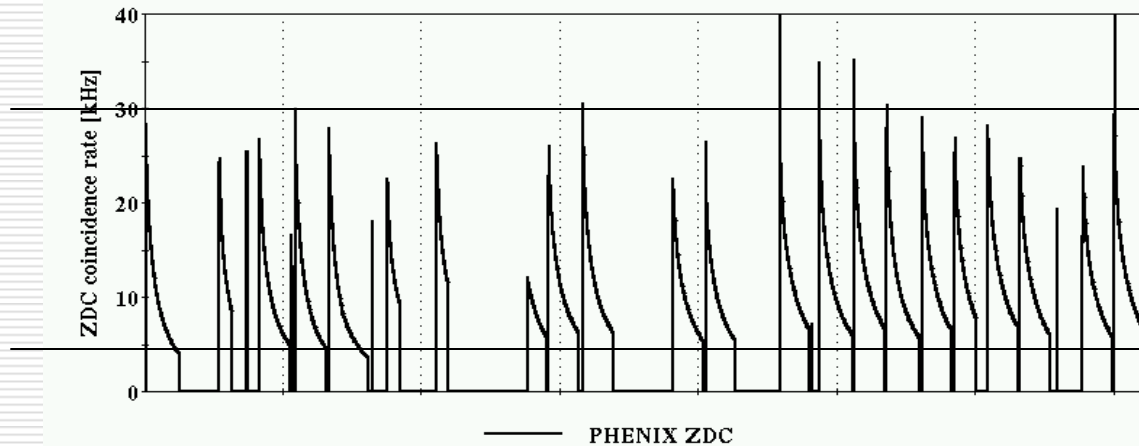- We reached the enhanced design goal!

run	year	$\beta*$ (m)	no. of bunches	ions/bunch 10^9	$\epsilon_{x,y}^{norm.}$ (π mm mrad)	$\mathcal{L}_{peak}$ (10^{26}cm^{-2}s^{-1})	$\mathcal{L}_{avg.}$	$\mathcal{L}_{week}$ (μb^{-1})
design		2	55	1.0	15-40	9	2	50
enhanced design		1	111	1.0	15-40	30	8	300
Run-2	FY2001/02	1	55	0.5	15-40	3.7	1.5	24
Run-4	FY2004	1	45	1.1	15-40	15	5	160
Run-7	**FY2007**	**0.8 (1.1?)**	**111**	**1.1**	**15-40**	**30**	**10-14**	**200-400**

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Scrubbing at the beginning of the run
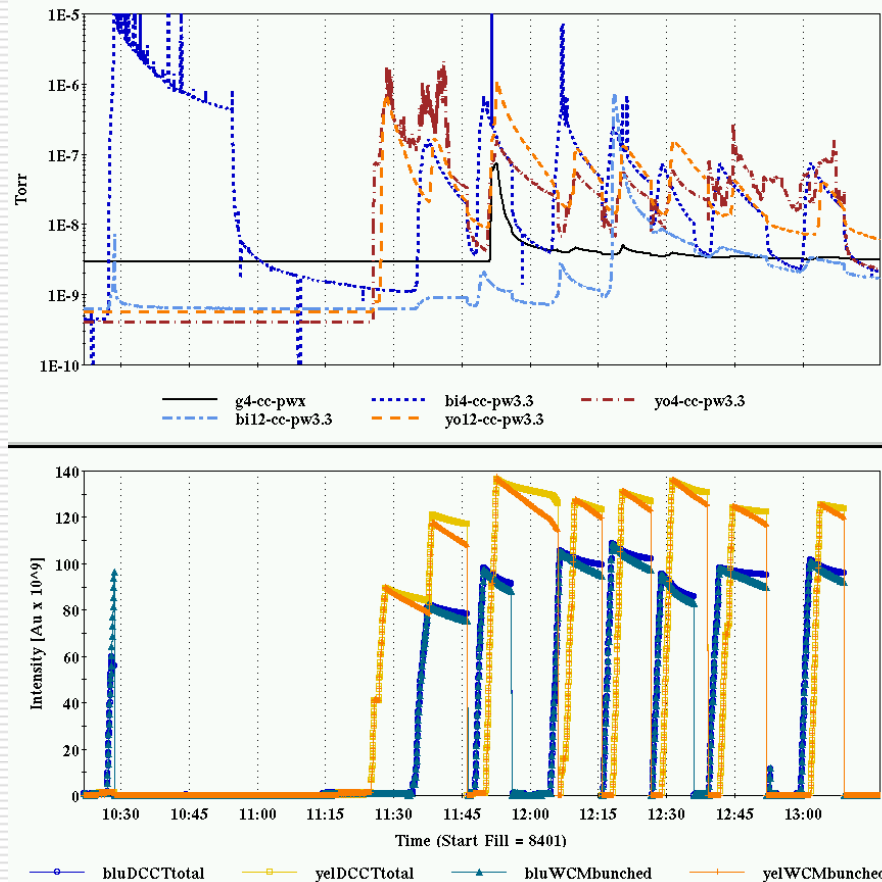
- Pressure bump moves from IR4 to IR12
- Pressure bump reduces after 4th high intensity injection
- Spend a total of 2 hours

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Example of a good week (May 14-May 20)

Peak luminosity of 30 10^{26} cm^{-2} s^{-1}
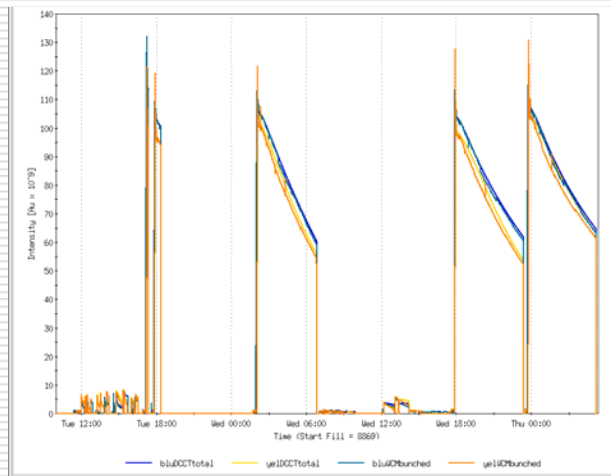
Avg. store luminosity
of 8 10^{26} cm^{-2} s^{-1}

- This weeks integrated luminosity totaled 380 μb-1
- Stochastic cooling effect clearly visible
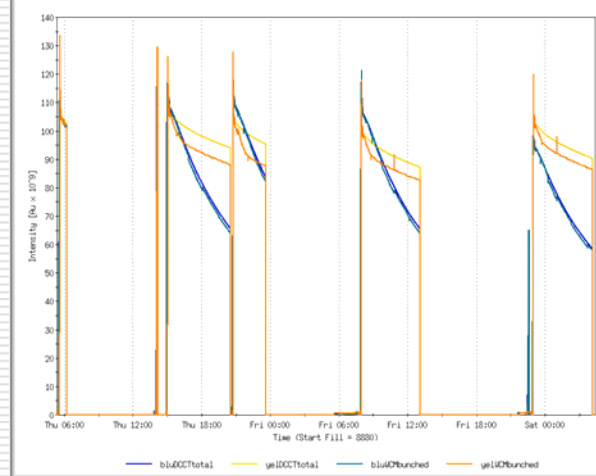- Initial beam intensity routinely above 120 10^9

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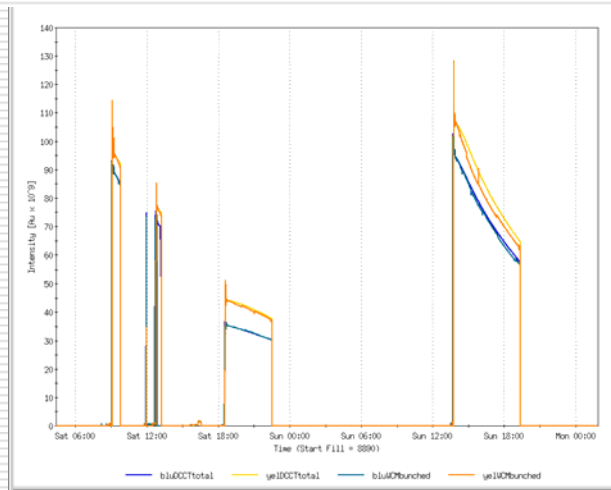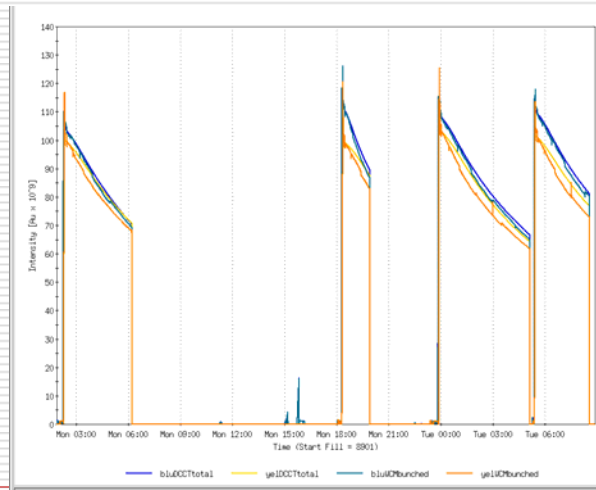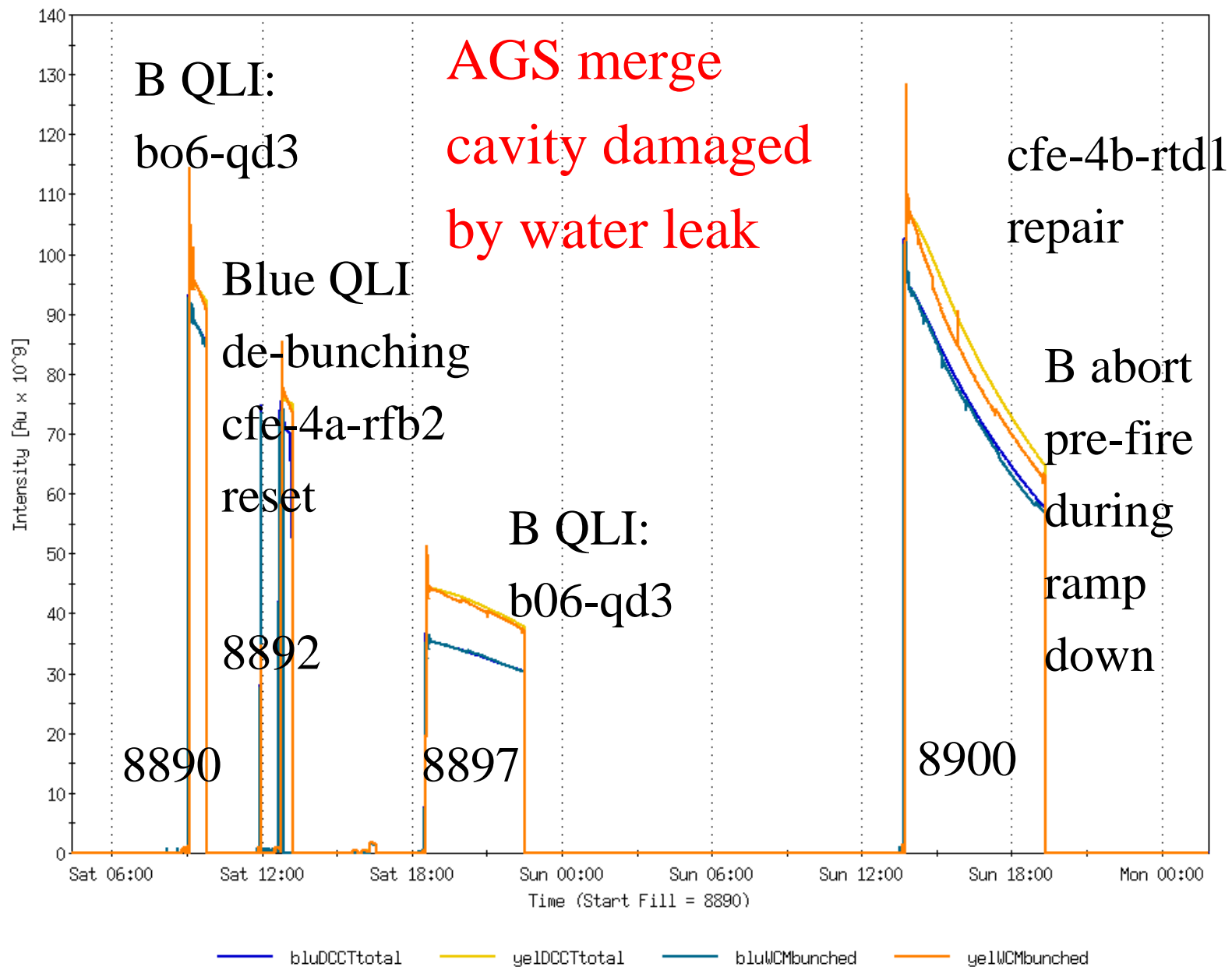# Example of a bad week May 28 – Jun 3
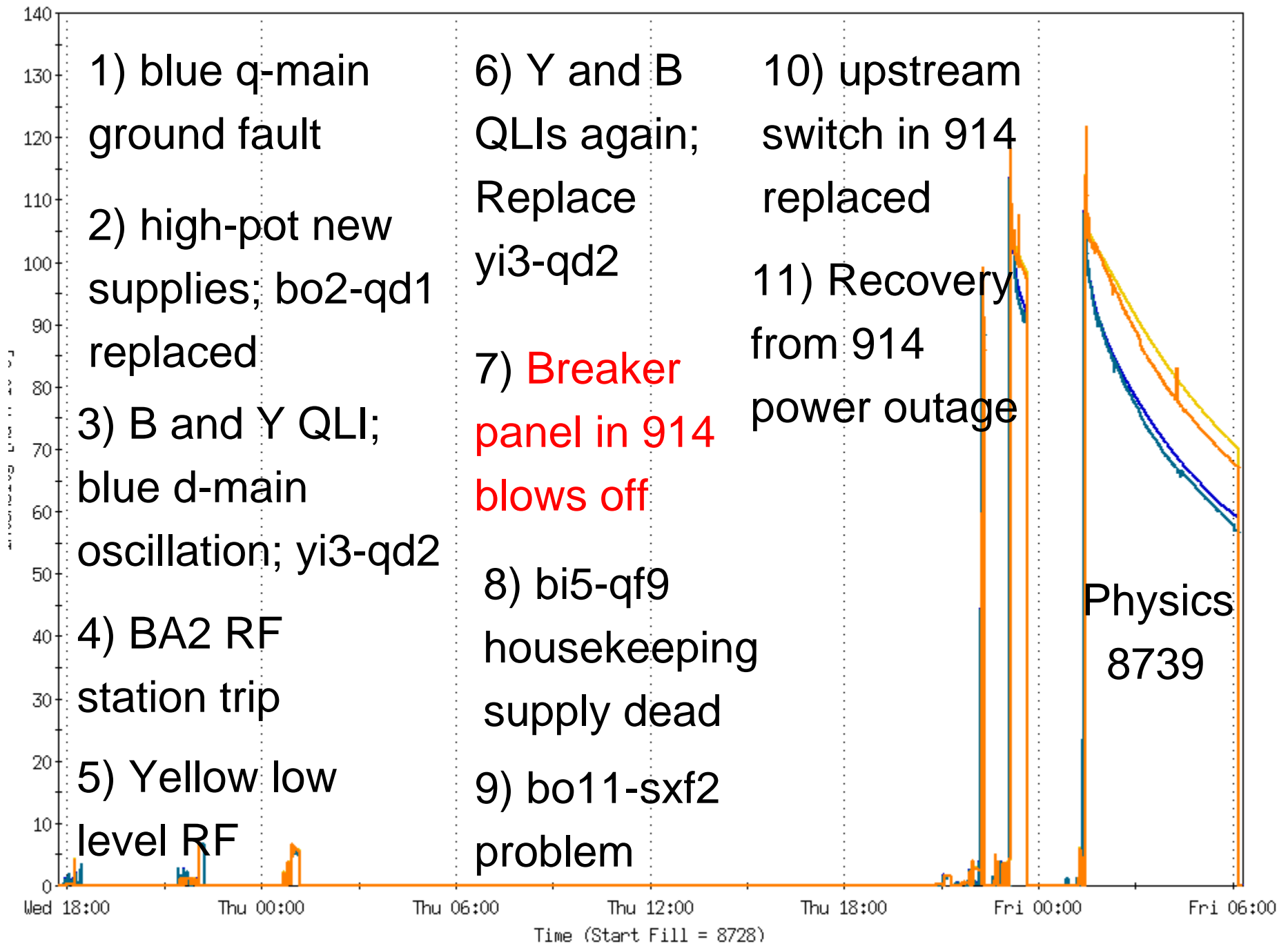

Tue-Wed

Thu-Fri

Sat-Sun

Sun-Mon

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1) blue q-main ground fault

2) high-pot new supplies; bo2-qd1 replaced

3) B and Y QLI; blue d-main oscillation; yi3-qd2

4) BA2 RF station trip

5) Yellow low level RF

6) Y and B QLIs again; Replace yi3-qd2

7) Breaker panel in 914 blows off

8) bi5-qf9 housekeeping supply dead

9) bo11-sxf2 problem

10) upstream switch in 914 replaced
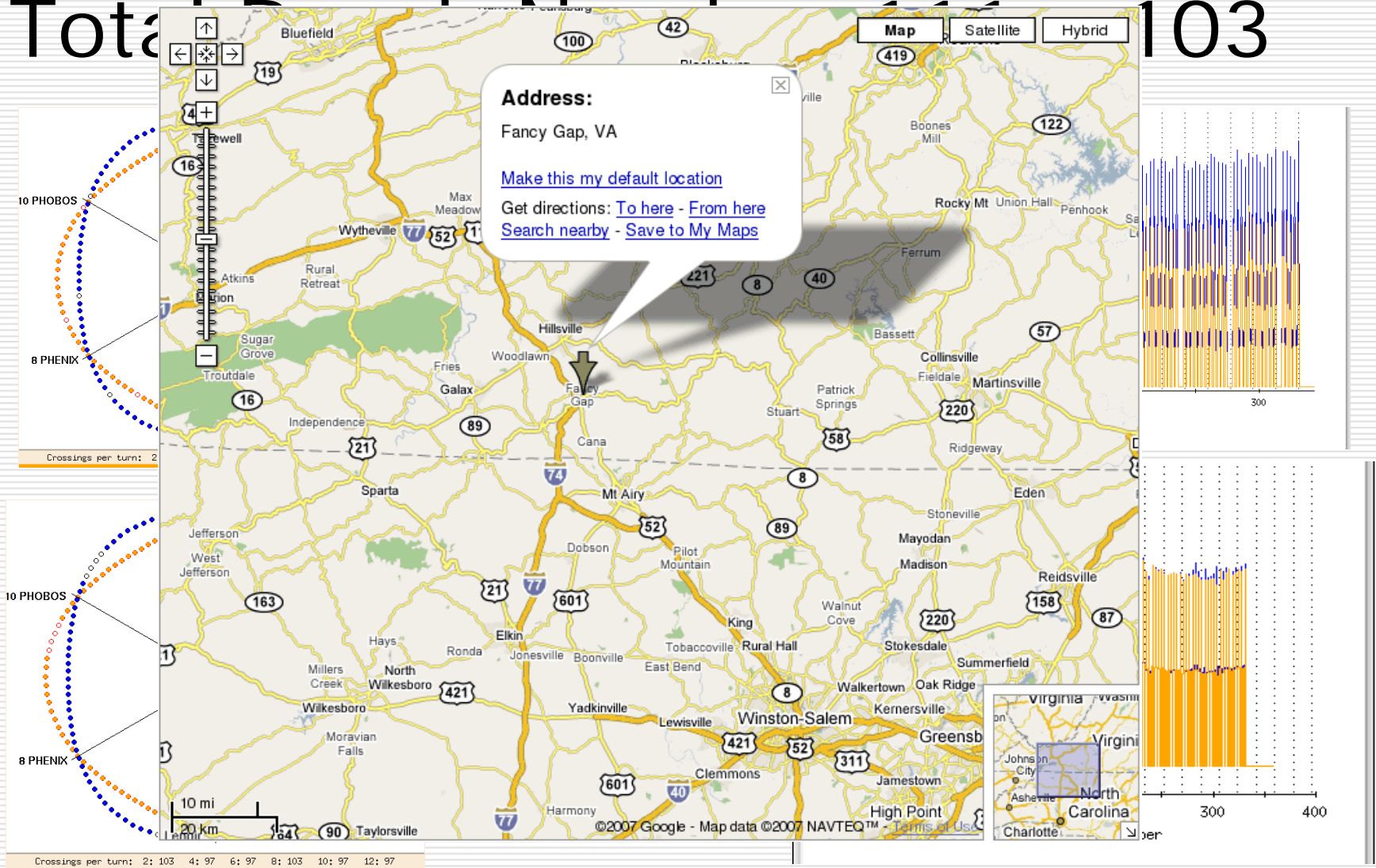
11) Recovery from 914 power outage

Physics 8739

Time (Start Fill = 8728)
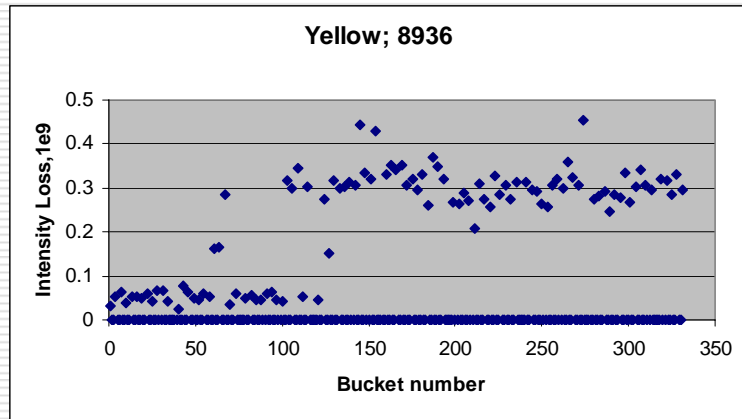
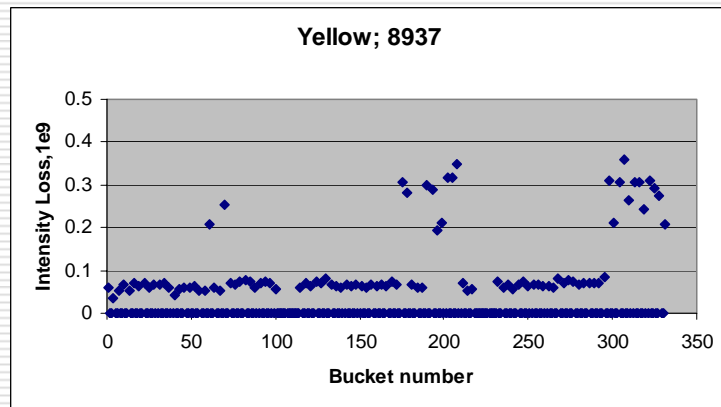- beam losses along the bunch train
- Rebucketing issues, debunching beam
- Higher bunch intensity?

Losses along the bunch train

1o3
Std.

Yellow; 8936

103
f.g.

Yellow; 8937

- ☐ 103 std. ramp (1.15) shows beam blow up in all late bunches (ramp failed)
- ☐ Next 103 fg ramp with same bunch intensity (1.17) worked
- ☐ Gap pattern clearly visible in 8837
- ☐ 103 fg set to be default

Stochastic Cooling (Yellow only)

- Stochastic cooling was commissioned and made operational for the 2nd half of the run
- Yellow beam decay reduced to "burn-off" rate
- More beam in the center bucket
- Increased luminosity lifetime
- Net-effect on integrated luminosity 10%-20% (analysis not yet finished)
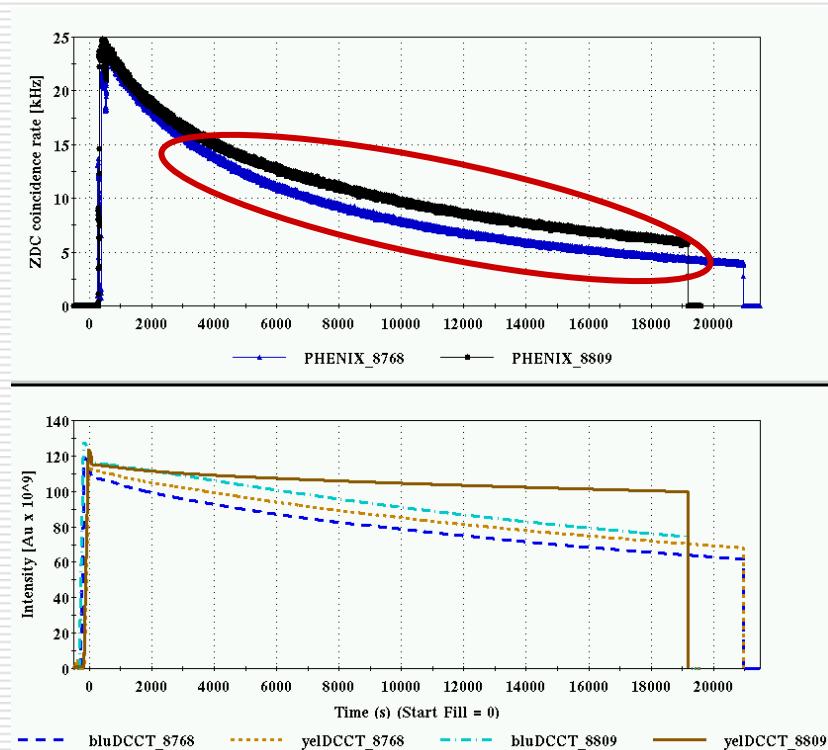
Bunch Intensity at Injection
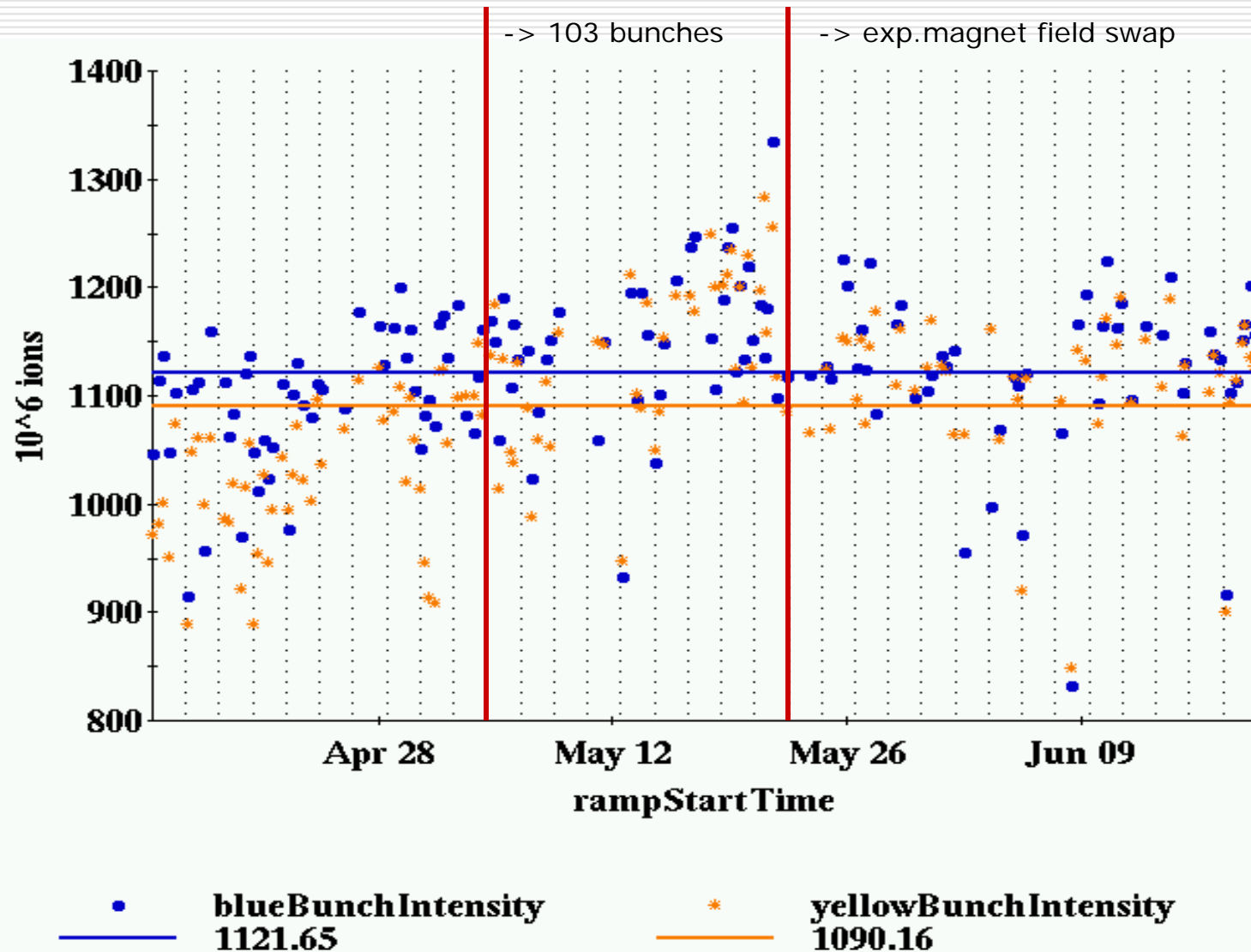
Ramp Efficiency
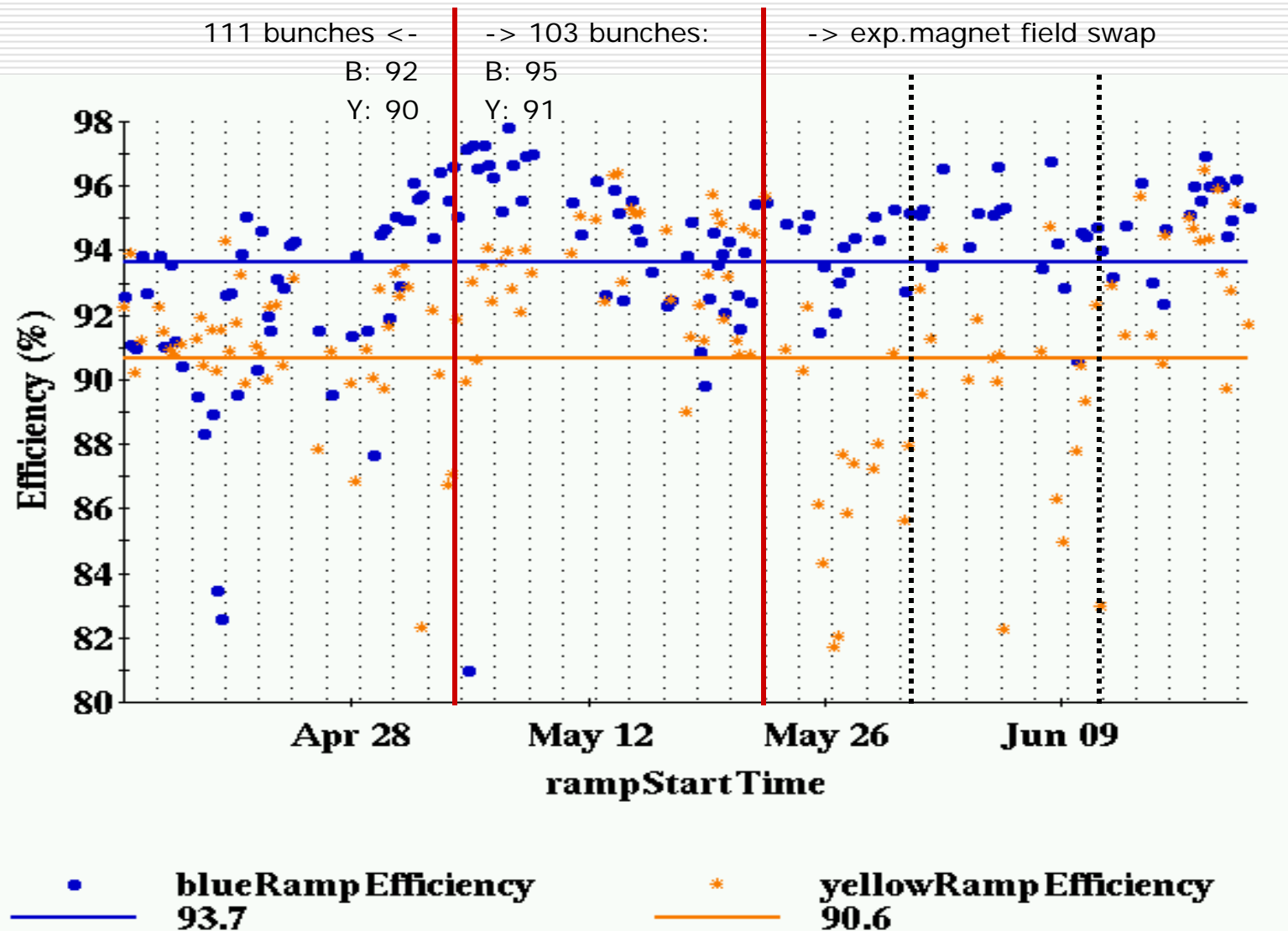
Time between newfill and accramp (turn-around indicator)

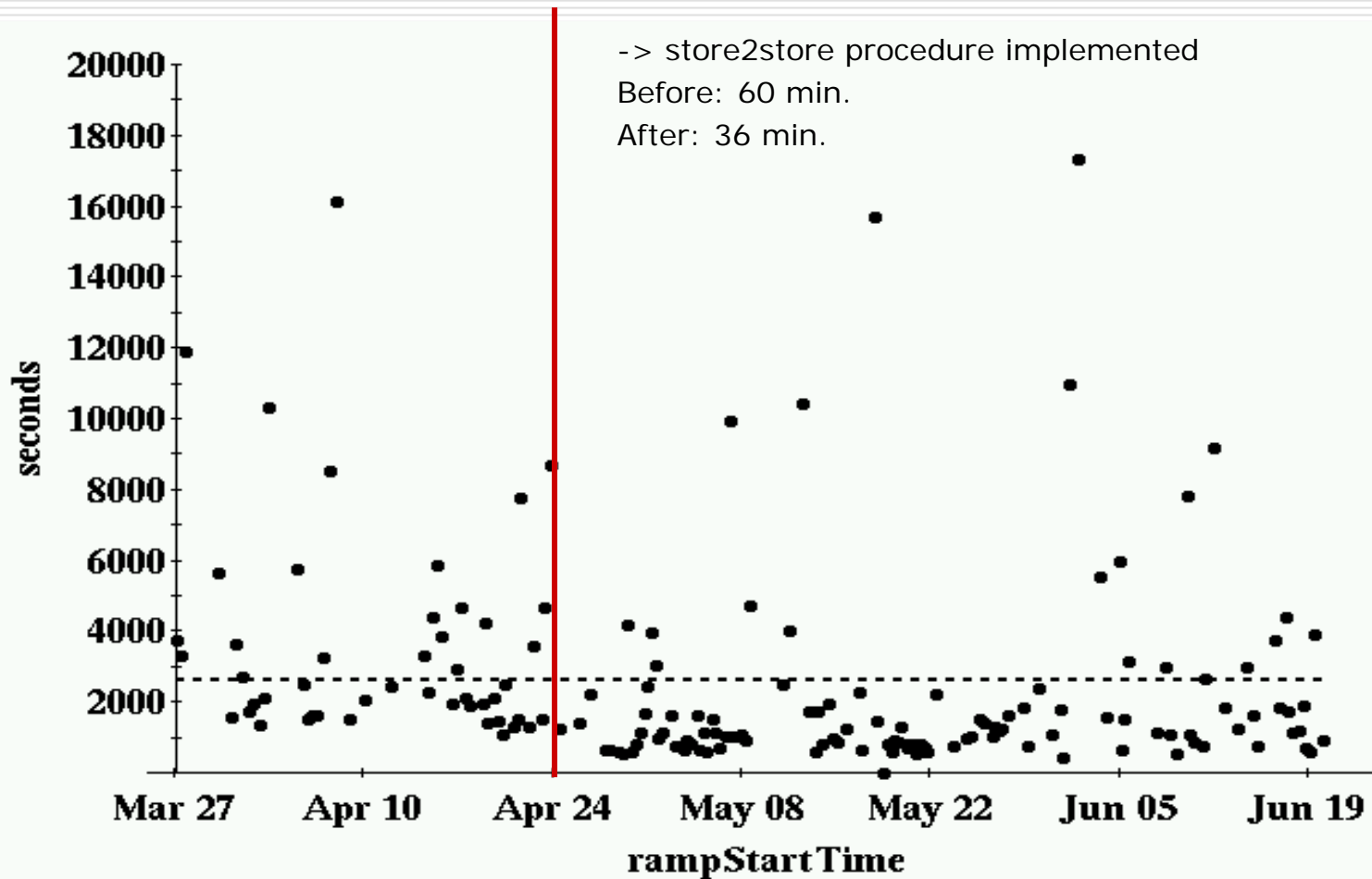# Run7 average luminosity highest with 103 bunches/ring
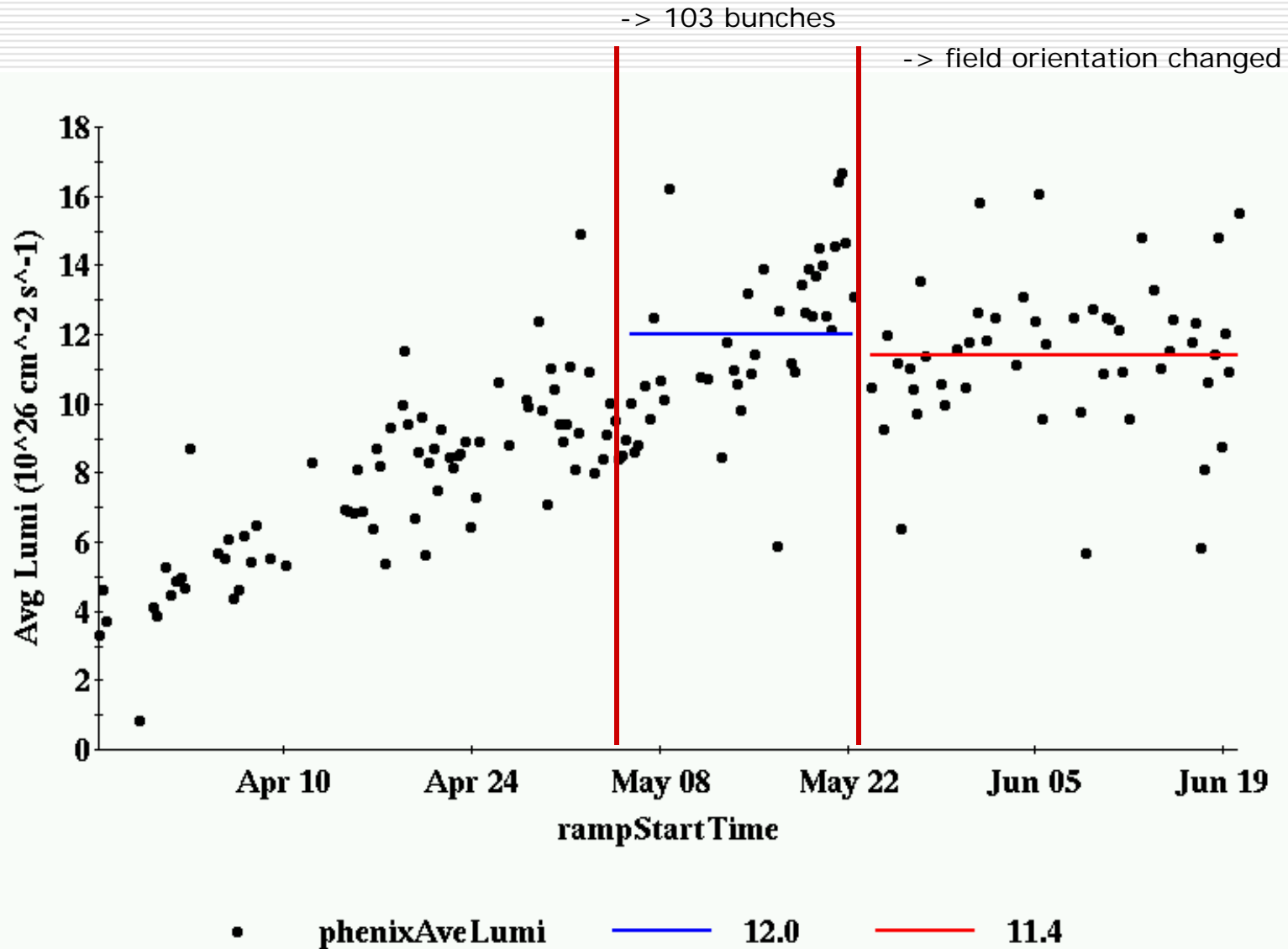
Low Energy study: Challenges and Successes

- Challenges
  - h=366 invalid events stopped PHENIX, nearly stopped STAR, interfered with V125 abort trigger module
  - 3-bucket cogging in h=366 prevented simultaneous expt cogging
  - Unipolar defocusing sextupoles limited chromaticity to near zero
  - Minor online model issues prevented full range of tune adjustment
  - All challenges are addressible either offline or during test run setup

- Successes
  - LLRF worked like a charm, RF capture quick with phase detectors
  - Instrumentation worked remarkably well with h=366 timing
  - Orbit correction, coupling corrections worked well
  - Longitudinal beam distribution shorter than expected (scraping?)
  - Vernier scans still feasible even with 2-20 minute beam lifetimes
  - Have data for luminosity measurement deliverable

Setup within 24 hours!

Low Energy: STAR Vernier Scans
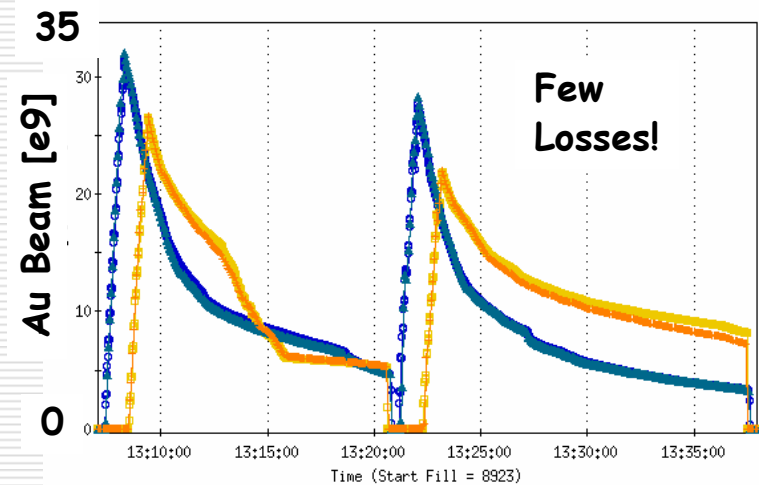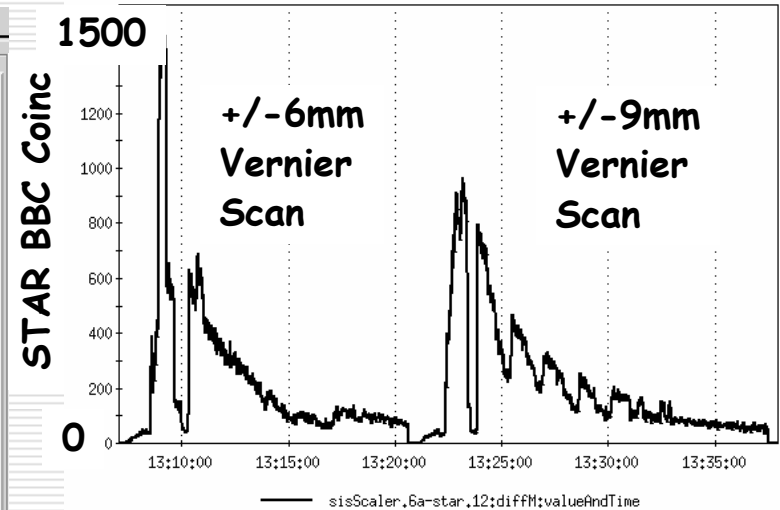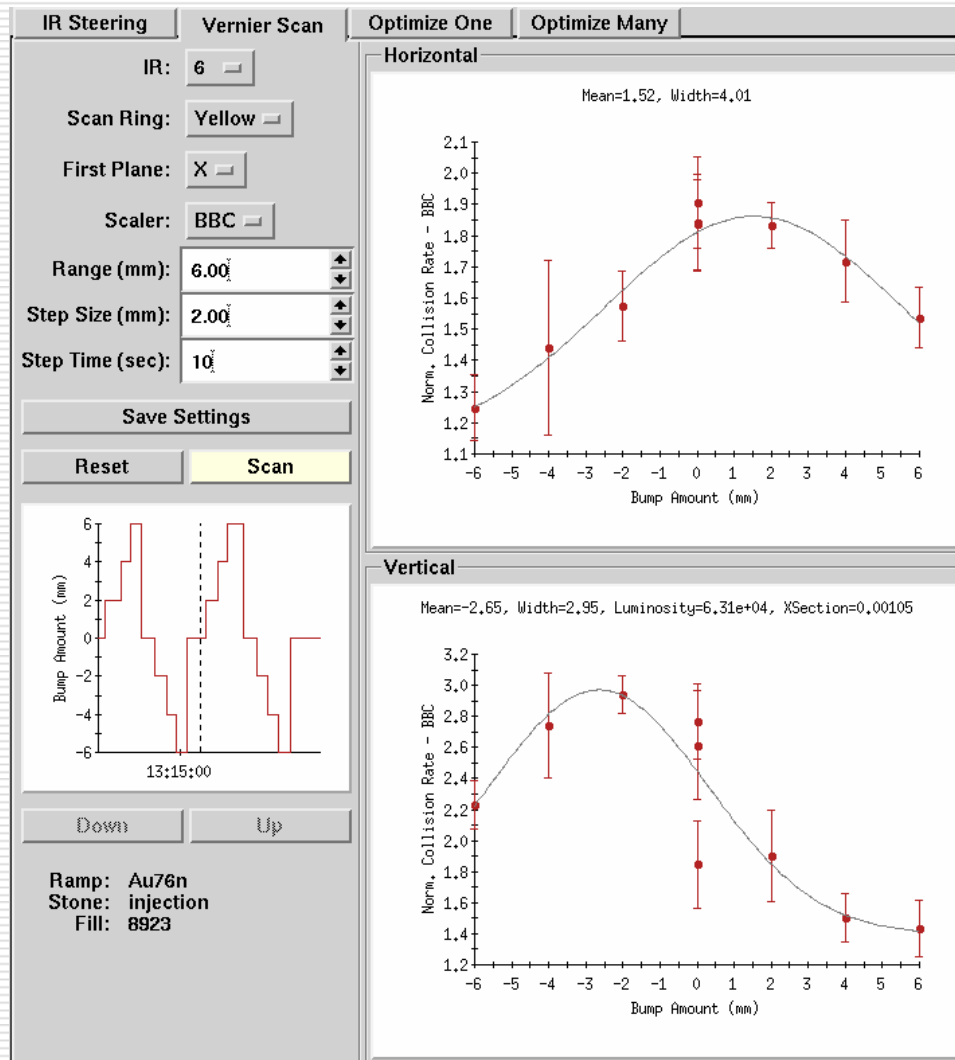
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Courtesy T. Satogata

Run7

hours

168
144
120
96
72
48
24
0

Legend:
- failure
- Scheduled Shutdown
- maintenance
- machine setup
- experimenter setup
- beam studies
- machine development
- physics

week

Week	physics	experimenter setup	machine development	beam studies	machine setup	maintenance	Scheduled Shutdown	failure
03/20/07/2 to 03/27/07/1	10	42			67			50
03/27/07/2 to 04/03/07/1	55		4		35	13		61
04/03/07/2 to 04/10/07/1	70		6	5	30			58
04/10/07/2 to 04/17/07/1	60		5	7	30	12		52
04/17/07/2 to 04/24/07/1	95		8	12	30			23
04/24/07/2 to 05/01/07/1	73		6	11	23	11		44
05/01/07/2 to 05/08/07/1	98		10	7	26			27
05/08/07/2 to 05/15/07/1	57		9	22	10		3	69
05/15/07/2 to 05/22/07/1	93		8	20			2	42
05/22/07/2 to 05/29/07/1	73		7	21	7			58
05/29/07/2 to 06/05/07/1	58		4	9	21			76
06/05/07/2 to 06/12/07/1	69		17	10	17	8		47

Run 7 Failures by system (to 6/12)

hours

174

801.5 hours

96

72

48

24

0

PS_RHIC, CryoRHIC, RRHIC, PPS_RHIC, RfAGS, QuenchProtect, ACG_RHIC, ElecRHIC, PS_Experiment, ESHQ, WaterAGS, InstRHIC, CntrlsHdRHIC, ES&FD_AtR, QLI, HumanError, PS_Bstr/BtA/LtB, ElecBooster, RadMonIntlk, ElecAGS, ElecAtR, ACG_Boost, QuenchDetect, Weather, ES&FD_Exp, CntrlsSftwr, TfB, InstBooster, VacRHIC, TMP7, PPS_Booster, InstAGS, VacAGS, InjPerformance, RfBooster, PS_AGS, CntrlsHdBoost, CoolACAtR, PPS_AGS, CntrlsNtwrk, WaterRHIC, WaterBoost/BtA, ACG_AtR/V, IceBall, VacBooster, VacAtR

system

Week-by-week integrated luminosity Run 7

Run 7 (AuAu) -- Integrated Luminosity (singles corrected)

■ Phenix   ■ STAR   ■ (lumi) hours at store

thru store 9008
ending 08:43 19 June

goal

avg.
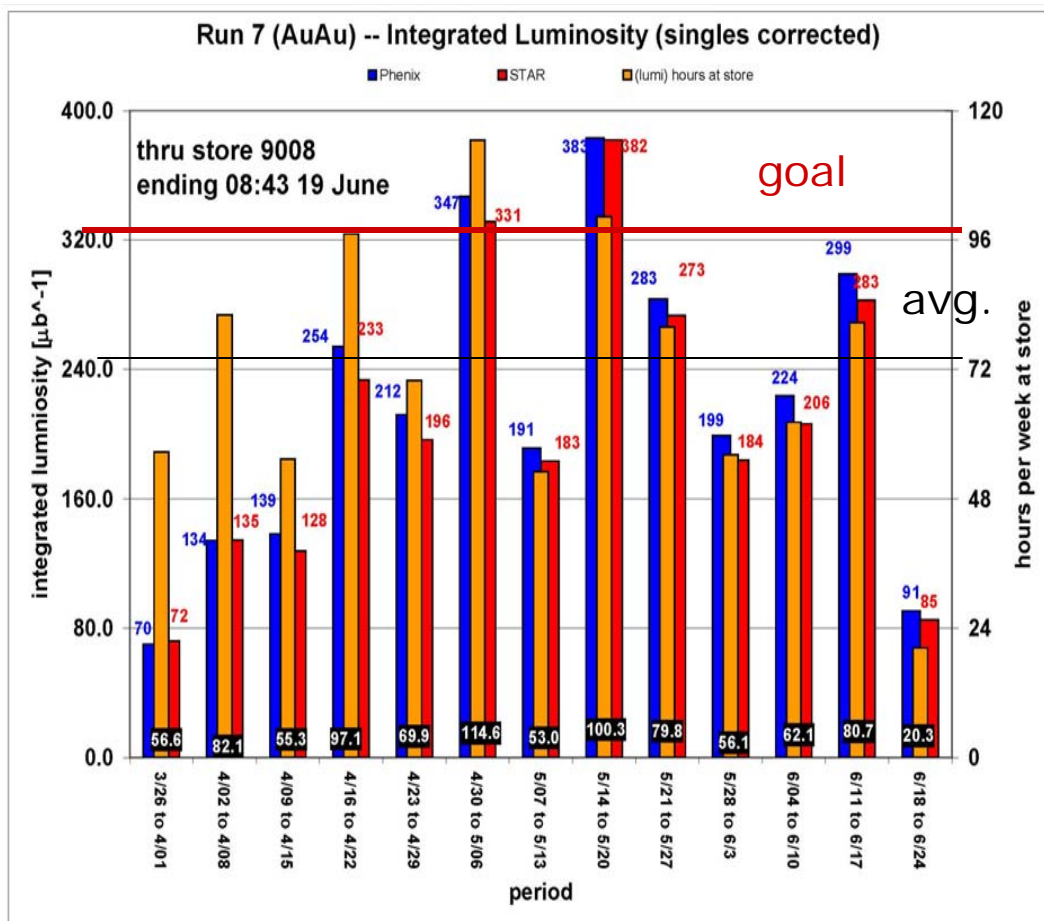
- ☐ Only 2 weeks above goal
- ☐ Contributing factors:
  - ■ Temperature (late start of run), weather
  - ■ Full field (Au @ 100 GeV)
  - ■ Unprecedented intensity (beam loading)
  - ■ Pushing the envelope (transition crossing, pressure rise, number of bunches etc.)
 - ■ Aging?

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Time at store

- Data included until Jun 9th 2007
- Goal: 60%
- Failed to reach goal by 15%
- Break up into week-by-week on next slide
- Beam induced quenches not correlated with uptime

Beam induced quenches:
46   69   54   37   18 41
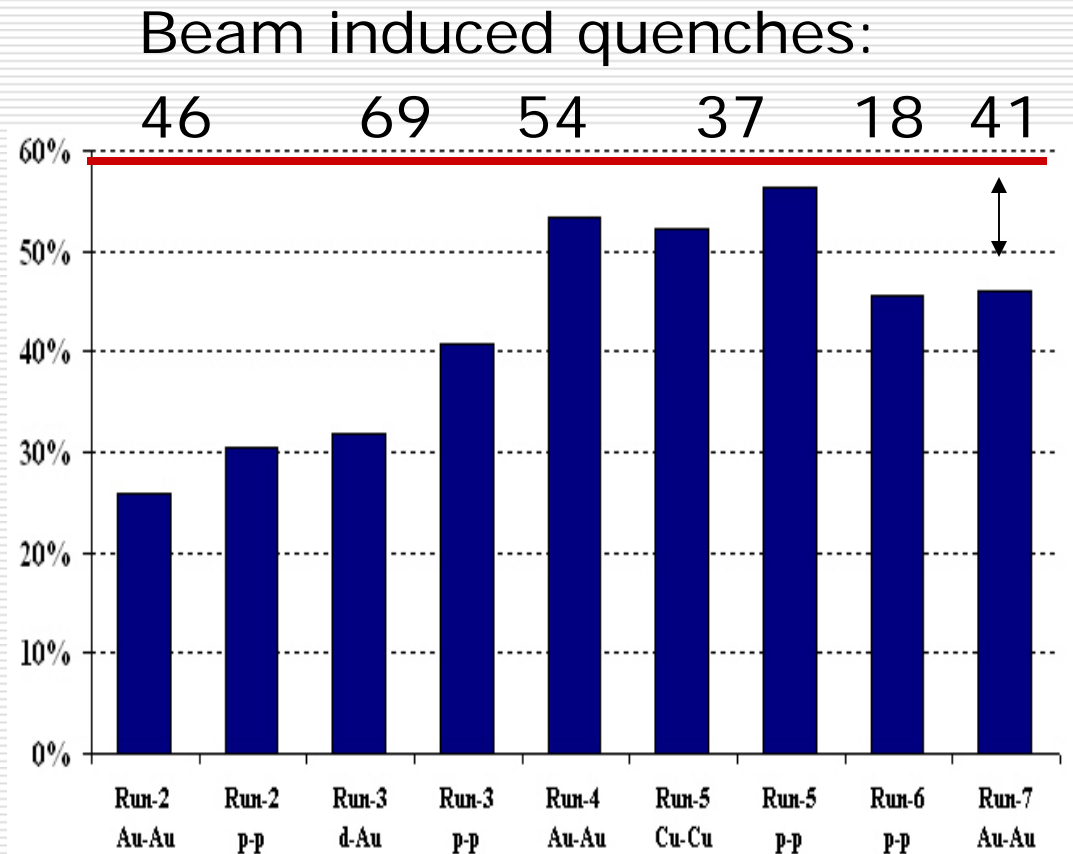
Integrated Au-Au Luminosity Run-7

- Integrated luminosity well between min. and max. expectation
- Corrected for acc. collisions (due to high coll. rate)
- "bi-weekly" performance oscillation coinciding with maintenance days
- Slope change after experimental magnets polarity flip
- Integrated luminosity still in upper half even with only 40% time at store!

Run7 RHIC AuAu   Integrated Luminosity for Physics (singles corrected)

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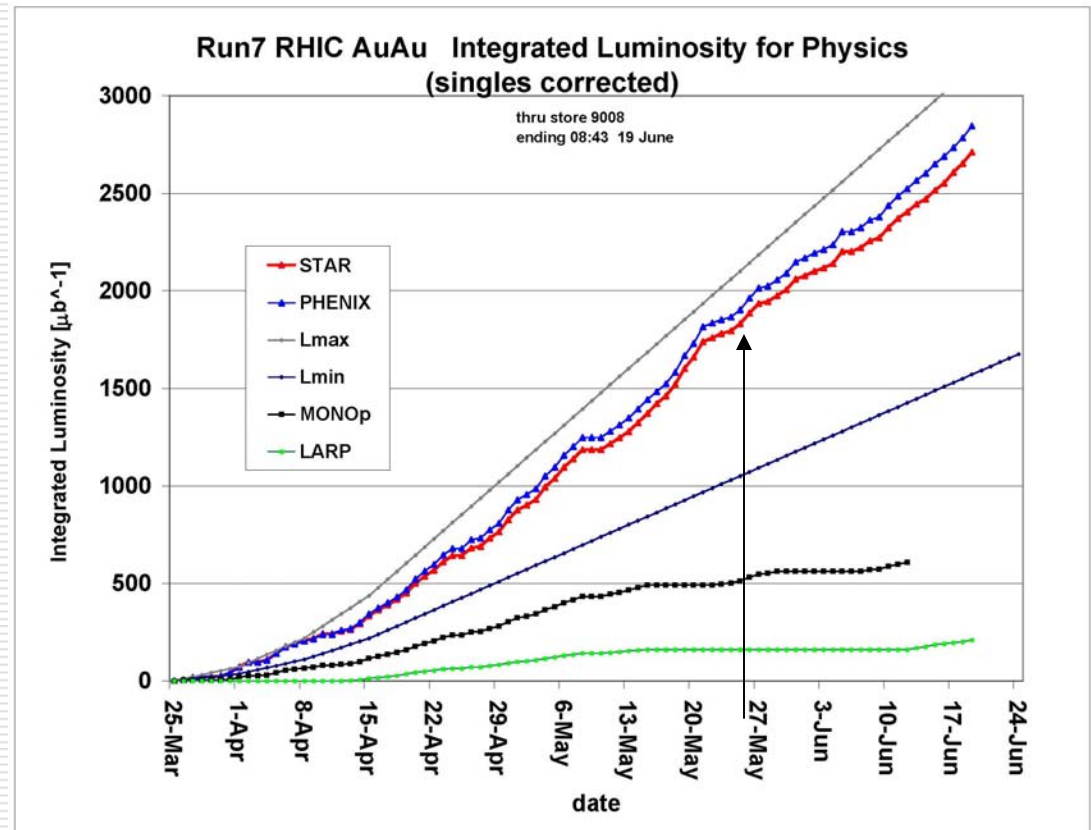
Conclusions

- Analysis of data not yet finished (Run still going on!)
- We met our goals (almost)
  - 111 bunches
  - Exceeded 8 10^{26} cm-2 s-1 avg. luminosity/store
  - 30 10^{26} cm-1 s-1 peak luminosity
  - Some weeks exceeded 300 ub-1 integrated luminosity
- Bunch intensity limit (~1.2 10^9)
- Up-time or reliability needs significant changes:
  - Plans for next year
  - Long-term plans
- Stochastic Cooling concept worked very well
  - Need to work on mechanical design